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ABSTRACT

Mars has been a popular image with students, particularly because of the idea of Martians. This document presents lesson ideas and provides support for teachers on information concerning Mars. (YDS)

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SMITHSONIAN IN YOUR Classroom

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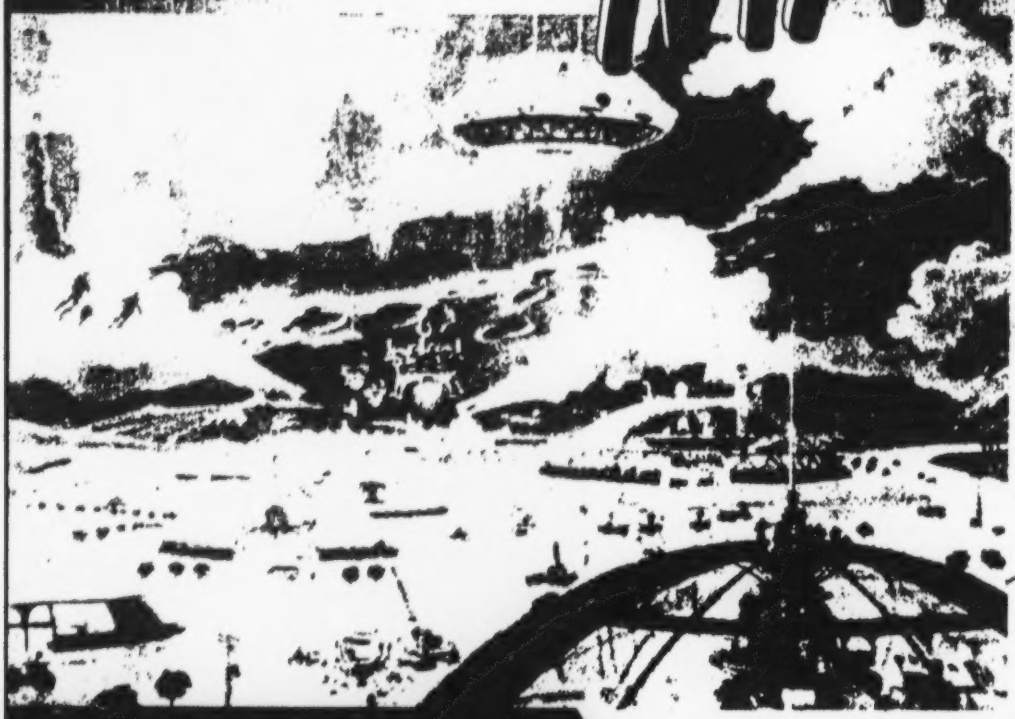
WHAT TO MAKE OF MARS



SUBJECTS

- History
- Science
- Visual Arts

GRADES 3-8

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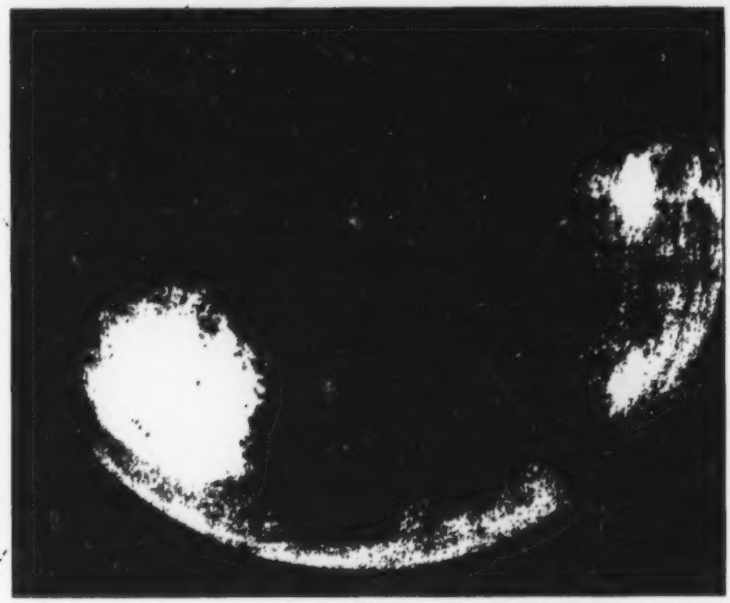

Mars in a mosaic of three photos taken by *Mariner 9*.

The purpose of *Smithsonian in Your Classroom* is to help teachers bring to their students the educational power of museums and other community resources. It draws on the Smithsonian's exhibitions and programs—from art to zoology—to create classroom-ready materials for grades 3–8.

Each of the four annual issues takes an interdisciplinary approach to a single topic. The Smithsonian invites teachers to duplicate *Smithsonian in Your Classroom* materials for educational use.

You may request an audiotape, large-print, braille, or disk version (Mac or PC) by writing to the address listed on the back cover or by faxing your name, school name, and address to 202-357-2116. Please specify the issue you are requesting.

What to Make of Mars addresses the following standards:

National Science Education Standards
- *Science as a Human Endeavor*
- *Nature of Science*
- *History of Science*

National Standards for World History
- *Historical Analysis and Interpretation*
- *Historical Research Capabilities*

You can find resources that address national standards for dance, music, theater, and visual arts at **www.mars2030.net.**

The U.S. Department of Education does not mandate or prescribe particular curricula or lesson plans. The information in this document is provided only as a resource that educators may find helpful and use at their option.

Cover: *Terraforming Mars* by Robert McCall. Courtesy of the artist.

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Cover, page 9: Robert McCall

Pages 2, 3, 4, 6, and 14: National Air and Space Administration

Page 5: National Air and Space Museum

Page 7: Lowell Observatory

Page 8: Everett Collection

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Page 12: National Museum of Natural History

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IN OUR PROGRESS

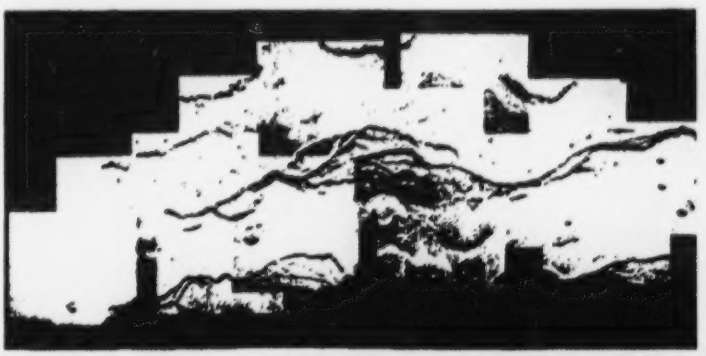
toward an understanding of Mars, art has sometimes preceded science. The Mars of the popular imagination—the Mars fertile enough to support Martians—seemed disproved once and for all in 1965, when the *Mariner 4* probe took twenty-two photographs of a barren, dead, crater-pocked surface. Then, just six years later, *Mariner 9* entered the Martian orbit for a better look and discovered a different world entirely. There were Earth-like features unearthly in scale—volcanoes more than twice as tall as Mount Everest, a canyon system that would stretch from Los Angeles to New York. Even more startling were valleys and channels shaped by ancient floods. With this evidence of water came the possibility of finding some sort of Martian life after all.

In 1976, the Viking mission moved us to a microscopic view of the planet. Each of the two craft, *Viking 1* and *Viking 2*, consisted of an orbiter and a lander. The landers touched down softly and safely on opposite sides of the planet and went to work analyzing the soil. While the tests found nothing organic, images from the orbiters showed the presence of permafrost beneath the planet's surface and water ice within its carbon-dioxide polar caps.

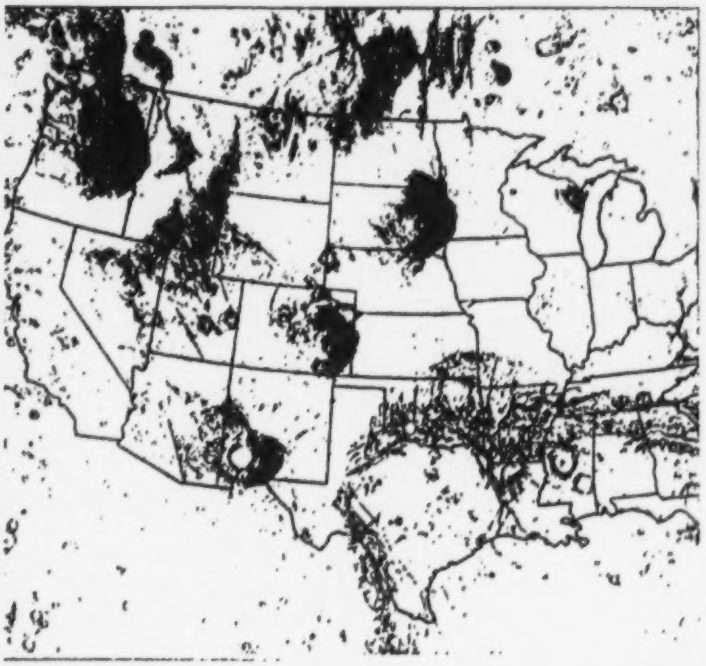
In 1984, a possible encounter with Martian life occurred on Earth. An American expedition in Antarctica came upon a meteorite formed on Mars more than four billion years ago. In 1996, a team of NASA scientists announced that microscopic structures embedded in it may be the fossils of Martian bacteria.

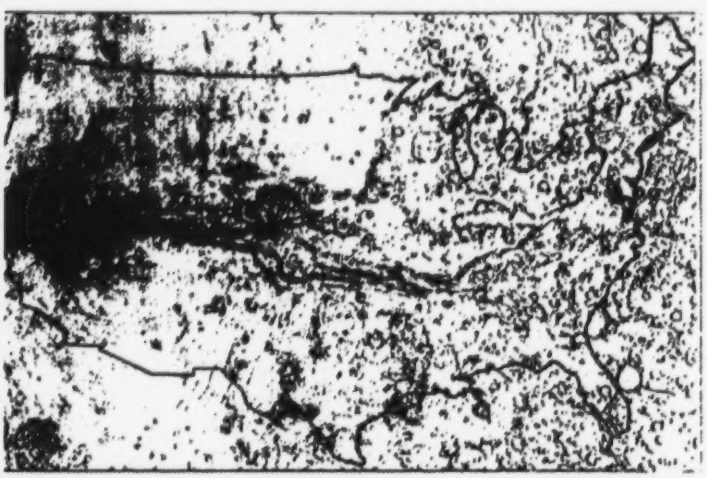
The finding, though far from conclusive, was enough to prompt President Clinton to call for a summit on the future of Mars missions. A verifiable discovery of extraterrestrial life, however primitive, would have implications comparable to Copernicus's discovery that the Sun does not revolve around the Earth. It would lead, perhaps, to a consideration of life in the universe as something more like a rule than a miraculous exception. NASA's long-range plan for Mars is a matter of following the water, a search for places that might have supported life in the past and might also support human expeditions, perhaps by the second decade of the new century. When we look even that far ahead, though, the imagination comes back into play. As the recent losses of the *Mars Climate Orbiter* and the *Mars Polar Lander* have shown, science still does not have a lock on the planet, and the future is anything but a done deal.

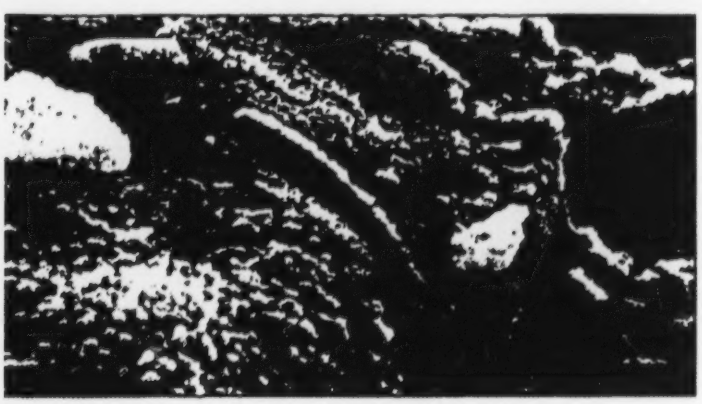
We would like, then, to encourage you and your class to create your own version of the future by taking part in the Mars Millennium Project, in which students envision a community on Mars—a colony of a hundred people in the year 2030. It is sponsored by the White House Millennium Council, the U.S. Department of Education, NASA, the National Endowment



Channel shaped by water, photographed by *Viking Orbiter 1*.







for the Arts, and the J. Paul Getty Trust. All the information you'll need is at their Web site, **www.mars2030.net.**

You are free to approach the project in any way you wish. You may design the entire community or focus on one scientific, social, or artistic aspect of it. The sponsors ask only that you follow these five steps:

1. Reflect. Investigate your own community. What is its history? How does it function? What makes it a community? What *is* a community?

2. Imagine. In what ways would the Mars community have to be different from your community? What would you retain to make the new world not only survivable but livable?

3. Discover. Research the conditions of Mars. Put these studies into perspective by looking at natural conditions on Earth as well.

4. Create. Represent the Mars community in some form (e.g., a painting, a model, a song, a dance, a play) and write a summary of your work.

5. Share. Take a look at the work of other classes on the Web site, and submit your own ideas.

As you can see, the project has as much to do with this world, and your corner of it, as with the planet Mars. The sponsors hope that the work will reveal connections between the past and the future, between science and art, and between people as well. Students may find in their own communities an interdependence similar to that between their imaginary colonists on Mars.

Top: **The great volcanoes of Mars, overlaid with a map of the United States for scale. Olympus Mons, the largest known mountain in the solar system, takes up almost all of the Pacific Northwest.**

Center: **The great canyon system Valles Marineris, named for *Mariner 9*.**

Bottom: **The worm-like shape is one of the hypothetical fossils found in the Martian meteorite. It is less than 1/100th the width of a human hair.**

MARS FROM AFAR

THERE IS NO SURFACE WATER ON MARS NOW. IT IS A FREEZING desert, but parts of it look for all the world like deserts on Earth, at least in black-and-white photos. When *Viking Lander 1* opened its camera eyes to the Martian surface, it revealed a landscape that could have been the setting of a John Ford Western or a biblical epic. "You can almost imagine the camels coming up over the dune into our view," said Thomas Mutch, the leader of NASA's photo-inspection team. But when the pictures were developed in color, Mars began to look like itself: the soil was red with iron oxides and the sky was ruddy with dust.

Mars shows its redness even to the naked eye, and many ancient cultures were alike in associating it with fiery violence. To the Babylonians, it was Nergal, the dwelling place of the god of death. It was Harmakhis to the Egyptians, Pahlavani Siphir to the Persians, Tui to the Norse, and Ares to the Greeks—all of these were the names of warrior gods. The god Mars was the Roman version of Ares.

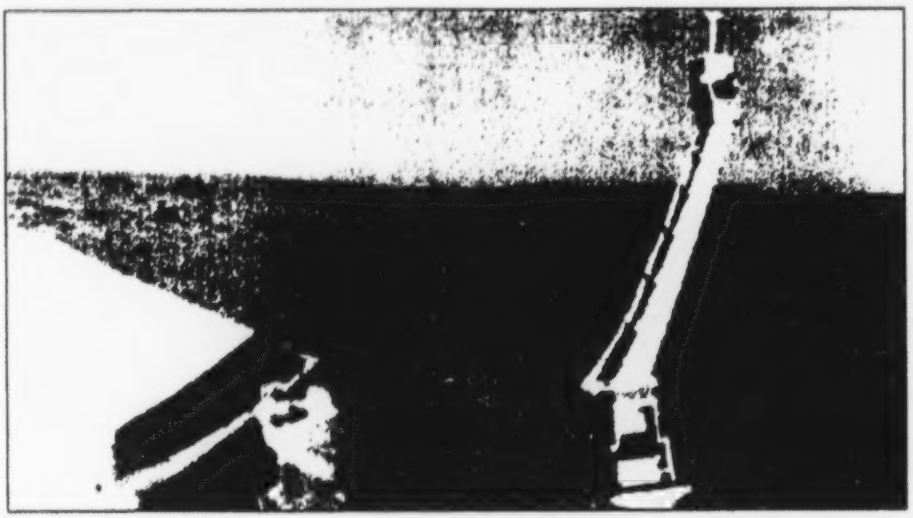
Johannes Kepler.

To the early observers, Mars was also distinguished by its movements. It was one of the bodies that the Greeks called *planetes,* or wanderers, because they appeared to glide against a fixed background of constellations. At times Mars wandered as if it were lost—it would stop and reverse its course.

This puzzle was solved in the early 1600s by the German astronomer Johannes Kepler. He deduced that the planets revolve around the Sun at different speeds, and that the retrograde motion of Mars is an illusion created when Earth, in its faster revolution, overtakes it. He could not, however, make his calculations fit into his assumption that the heavens are perfectly circular in shape and motion, an idea inherited from Greek philosophy, adopted by Christianity, and left alone by Copernicus. He applied a new mathematical formula and discovered that the planet moves not in a circle but in an ellipse. This was the first of his three laws of planetary motion.

The second and third laws state that there is a relationship between motion and proximity to the Sun: a planet moves faster as it gets closer to the Sun in its elliptical orbit, and the time it takes to complete the orbit is proportional to its average distance from the Sun.

"Well, so what?" said Carl Sagan in his book *Cosmos.* "We might have a tendency to dismiss these laws as mere mathematical tinkering, something removed from everyday life. But these are the laws our planet obeys as we ourselves, glued by gravity to the surface



Viking Lander 1 on the surface of Mars. Visible to its right are trenches dug with its robotic arm.

	EARTH	MARS
Diameter	7926 miles	4222 miles
Average distance from the Sun	93 million miles	142 million miles
Atmosphere	Mostly nitrogen and oxygen	Mostly carbon dioxide
Rotation and revolution	24 hours 365 days	24 ½ hours 687 days
Number of moons	1	2 (Phobus and Deimos)
Temperature range	-128 F to 136 F	-199 F to 63 F
Weight of 100-lb. person (strength of gravity)	100	38

of the Earth, hurtle through interplanetary space. We move in accord with laws of nature that Kepler first discovered."

Kepler did not understand the reason for the laws; it was Isaac Newton, later in the century, who used them as the basis for the law of gravitation. He did, however, foresee their significance. "Ships and sails proper for the heavenly air should be fashioned," he wrote to Galileo in 1609. He knew that by bringing astronomy within the grasp of physics, he had bridged some of the distance between sky and Earth.

At the time he was publishing his findings, Galileo was just beginning his telescopic studies of the solar system. Mars, with its thin carbon-dioxide atmosphere, would be quite hospitable to observation in the age of the telescope. But, like anything perceived from afar, it would be subject to great misinterpretations.

THE MAKING OF THE MARTIAN

Percival Lowell in his observatory in Arizona.

IN 1877, GIOVANNI SCHIAPARELLI, THE DIRECTOR of the Brera Observatory in Milan, saw what appeared to be a network of long, dark, perfectly straight lines on the surface of Mars. In his reports of this he called them *canali,* a word that can mean any kind of channel or groove. In English translations, *canali* became the word it most resembles, "canals."

If there were canals on Mars, someone—or some*thing,* as they say in science fiction—must have built them. The inexact translation, which Schiaparelli coyly declined to correct, sent astronomers rushing to their telescopes. One of the few who saw the lines was an amateur, Percival Lowell of the wealthy Boston Lowells. To study them more closely, he built the Lowell Observatory outside of Flagstaff, Arizona.

In three books for a popular audience, he made speculations that were, however wild, thoroughly reasoned. The lines were indeed canals, he declared, and were most likely used to transport water from the polar caps to the arid regions of the planet. Anticipating the objection that these would have to be awfully wide canals to be seen through a telescope, he said that "it is always the strip of verdure, not the canal, that is visible, as we see in looking from afar upon irrigated country on the Earth."

Lowell believed Mars to be an older planet than Earth, so it followed that its civilization would be more advanced. He found evidence of this in the canals: "A mind of no mean order would seem to have presided over the system we see,—a mind certainly of more comprehensiveness than that which presides over the various departments of our own public works. Party politics, at all events, have had no part in them; for the system is planet wide."

We now know that there is not a single canal on Mars, so what were these lines?

The only explanation is that they were produced by the eye's tendency to find order in random markings, an illusion that may have been helped along by wishful thinking. As Carl Sagan once said of Lowell, "There is no question that the straightness of the lines

is due to intelligence. The only question concerns which side of the telescope the intelligence is on."

In 1898, three years after Lowell's first book on Mars, H.G. Wells published *The War of the Worlds*, in which Martians look upon Earth with envy from their dry and dying world. In their advanced evolutionary state, they are octopus-like—all head and arms, no heart. Humankind is no match for them when they stage an invasion.

A decade later, Edgar Rice Burroughs, the creator of Tarzan, began a series of tales set on Mars, in which he populated the grid of Lowell's canal system with green humanoids. The hero of the stories is Captain John Carter, a gentleman adventurer, who is able to transport himself there by a force that, conveniently enough for the author, is too mysterious for words. Merely by closing his eyes and holding out his arms toward the sky, he is "drawn with the suddenness of thought through the trackless immensity of space."

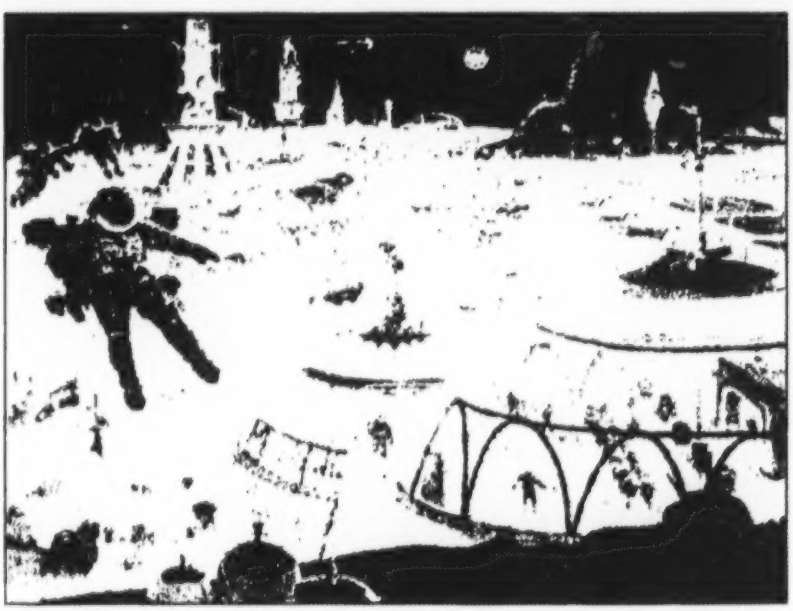
Not long after landing, he meets a beautiful princess, Dejah Thoris, who is of a copper-complexioned species older than the green creatures. They built the canals long ago, as the planet's great oceans were drying up, and they maintain atmosphere factories to keep the thinning air breathable. Like Wells's Martians, they have the means of spying on other planets, although the princess does not at first recognize Captain Carter as a man of Earth. Their view of us from above, she tells him, is obscured by the "hideous contraptions" that we call hats.

Thanks largely to Burroughs and Wells, Martian became a kind of brand name for extraterrestrials. In 1971, on the eve of the *Mariner 9* discoveries, the California Institute of Technology hosted a discussion on the subject of Mars and the imagination. One of the panelists was Bruce Murray, a geologist for the Mariner missions, who complained that scientists hoping to find life on Mars were as guilty of perpetuating "Lowell's legacy" as the science fiction writers had been. That hope, he said, amounted to an irresponsible preconception, and it had sometimes led to a misreading of facts.

Also on the panel was the science fiction writer Ray Bradbury, who had a different take. "I think it's part of the nature of man to start with romance and build to reality," he replied. "There's hardly a scientist or an astronaut I've met who wasn't beholden to some romantic before him who led him to doing something in life. I think it's so important to be excited by life. In order to get the facts, we have to be excited to go out and get them, and there's only one way to do that—through romance."

A scene from the 1953 movie *Invaders from Mars*.

LATE LAST YEAR, JUST AS NASA WAS BEGINNING TO GIVE UP hope of hearing from the *Mars Polar Lander*, Mars itself seemed to call again. Scientists at Brown University reported that they had found evidence supporting a hypothesis that an ocean once covered much of the planet. Photographs and height-measurement data from the *Mars Global Surveyor*, an orbiter launched in 1996, indicated long coastlines and terraces formed by the pounding of waves. If this proves true, it will make the Mars of Burroughs a little less fantastical.



Mars Metropolis: 21st Century, by Robert McCall, depicts a para-terraformed Mars.

So, too, will human colonization, if that is where we are headed. Since the seventies, there have been serious discussions of "terraforming" Mars, which means altering its environment to make it as habitable as Earth. NASA planetary scientist Christopher McKay has an idea of pumping chlorofluorocarbons into the atmosphere to create a greenhouse effect, which would be accelerated by giant sunlight-reflecting mirrors. A British scientist with a remarkably appropriate name, Martyn Fogg, has devised a plan to vaporize the underground water by setting off atomic bombs.

Plans that are somewhat less ambitious go by a more cumbersome term, "para-terraforming." On a para-terraformed Mars, humans would live in enclosed habitats—miniature Earths under roofs that would keep in oxygen and keep out the direct ultraviolet radiation Mars receives from the Sun.

Some para-terraforming enthusiasts think there could be self-sustaining communities on Mars by the middle of the twenty-first century. But even if we had to wait the thousands of years it would take to terraform the planet, even if we were to resolve all of the scientific and ethical questions, there might still remain a question that has been with us since the beginning of the space age: Why?

When President Kennedy asked the country to support the goal of reaching the Moon, his strongest appeals were to our least definable motives. "This is in some measure an act of faith and vision, for we do not know what benefits await us," he said in a speech in 1962. "Space is there and we are going to climb it."

In those terms, the very vision of extending ourselves beyond Earth is a part, perhaps the greatest part, of the act. The rest might only be an inevitable follow-through.

TAKE-HOME PAGES

WHAT'S WRONG WITH THESE PICTURES?

© 1950 The Hearst Corporation

AS YOU THINK ABOUT YOUR FUTURE COMMUNITY ON MARS, YOU might consider the ways that people imagined our time when it was still the distant future. Examining the pictures on these pages would be a start. "Cities of Tomorrow," on the next page, is from the August 1939 issue of the science fiction magazine *Amazing Stories*. The others are from a 1950 *Popular Mechanics* article titled "The Miracles You'll See in the Next Fifty Years," which tells the story of a family in the year 2000.

Does anything look like a prediction that came true? How many things are just plain wrong? If the pictures look more like their own times than the year 2000, do they give any clues to what those times were like?

© 1950 The Hearst Corporation

Cities of Tomorrow
The city of tomorrow, engineers say, will tend first to vastness; gigantic buildings connected by wide, suspended roadways on which traffic will speed at unheard of rates. This is the city the artist has pictured here. Traffic handled in huge underground tunnels, aerial ways, and in the air itself. Helicopter planes, capable of maneuvering about between buildings and roof-top airports, will take the place of the ground taxi. Each building will be virtually a city in itself, completely self-sustaining, receiving its supplies from great merchandise ways far below the ground. Dwellers and workers in these buildings may go weeks without setting foot on the ground, or the ground-level. In this city smoke will be eliminated, noise will be conquered, and impurity will be eliminated from the air. Many persons will live in the healthy atmosphere of the building tops, while others will commute to far distant residential towns, or country homes.
Copyright Amazing Stories, 1939.

© 1950 The Hearst Corporation

The waterproof home and "Cities of Tomorrow" are part of the Smithsonian exhibition *Yesterday's Tomorrows: Past Images of America's Future*, and are reprinted courtesy of the Smithsonian Institution Traveling Exhibition Service. *Yesterday's Tomorrows* toured the country from 1984 to 1986. It will be revived next year.

LESSON IDEA

MAKING HISTORY

The sponsors of the Mars Millennium Project encourage participants to use their community's past as a basis for the future community. One way of going about this is to include in the project a compilation of oral history. Students might interview parents and grandparents at home. The entire class might visit a nearby senior center or retirement home.

We offer here some guidelines adapted from *The Grand Generation: Interviewing Guide and Questionnaire,* an oral-history handbook by Marjorie Hunt of the Smithsonian Center for Folklife and Cultural Heritage. You can find the full text at our Web site, **http://educate.si.edu.** Click on Educator's Toolkit.

"The further backward you can look," Winston Churchill once said, "the further forward you are likely to see." This seems particularly applicable to the Mars Millennium Project, in which the future involves leaving behind the comforts of the present. If, for instance, the class project focuses on how to preserve Earth culture on Mars, a student could get some perspective by asking about a forebear's immigrant experience. If the class discusses the hardship of isolation in the Mars colony, there might be parallels in someone's memories of pre-electrification rural life.

We'd like to suggest that you also use the project to make a commemorative record of the year 2000 by asking questions along these lines:

When you were younger, what did you think life in the year 2000 would be like?

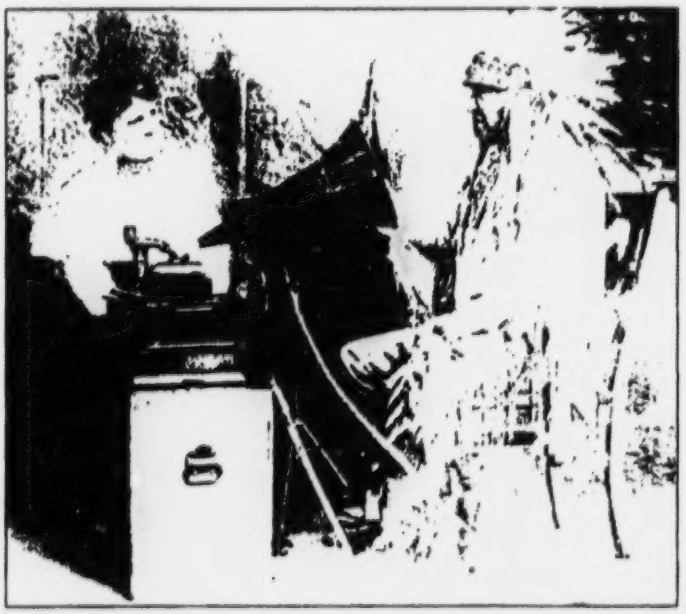
Are things better or worse than you thought they would be?

Oral history often concerns the intersections of personal history and history on a grander scale. The year 2000, as can be seen on the previous pages, has stood as a historical date in reverse—a demarcation of the future. Just as people remember exactly where they were when they heard of the attack on Pearl Harbor or the assassination of President Kennedy, most of us have at one time or another calculated how old we would be and imagined what we would be doing when we reached this momentous year.

The Equipment

Tape recording is the most common means of collecting oral history. It gives you a complete and accurate record of your informant's words and the subtler communications of voice—tone, inflections, pauses. It is a good idea, though, to keep a pen and paper with you during a tape-recorded interview so that you can note important points or jot down follow-up questions.

A portable cassette recorder and inexpensive normal-bias tapes will do just fine for the spoken word.



Smithsonian ethnologist Frances Densmore interviews Mountain Chief of the Blackfoot tribe in 1908.

Bring plenty of blank tapes, even more than you think you will need, so you won't get caught short.

Place the recorder so that it picks up both the narrator's voice and your own, and run a test before you begin. A standard procedure is to state your name, your informant's name, and the date and topic of the interview. This will also serve as an oral label of the tape.

The Interview

Before you begin, prepare a list of questions. They should be clear and concise but also evocative—that is, they should be designed to elicit fuller answers than yes or no. Do not, however, tie yourself to the list. Your informant may take up a rich subject that hadn't occurred to you.

Explain the purpose of the interview and how you will use the tapes. Even if your purpose is very specific, you might break the ice with general, easy-to-answer questions: *Where were you born? How many brothers and sisters did you have?*

Make sure your informant knows when you have turned the recorder on. Once the interview is in progress, keep it running—otherwise you may give the impression that his or her time is only selectively useful to you.

Afterwards

Label all the tapes with appropriate names, dates, and places. You might replay them and write an outline of their contents, which will be helpful if you need to find a certain segment of the interview.

We recommend that you ask your informant to sign a written release like the one on this page. If this seems a bit formal for a class project, remember that you are doing important work. You are contributing to the historical record, making something permanent out of memories that might have been lost entirely.

That said, the release should not entitle you to take possession of those memories. If the informant later asks you not to use a tape, or to erase part of it, respect his or her privacy and comply.

SAMPLE
INFORMATION AND RELEASE FORM

_____
Project name

_____
Date

_____
Interviewer

_____
Tape number

_____
Informant's name

_____

_____
Address

_____
Telephone number

_____
Hometown and state

_____
Date of birth

_____
Ethnic background (optional)

May we use this material for educational research and publications?
yes _____ no ____

May we include your name?
yes _____ no ____

_____
Signature Date

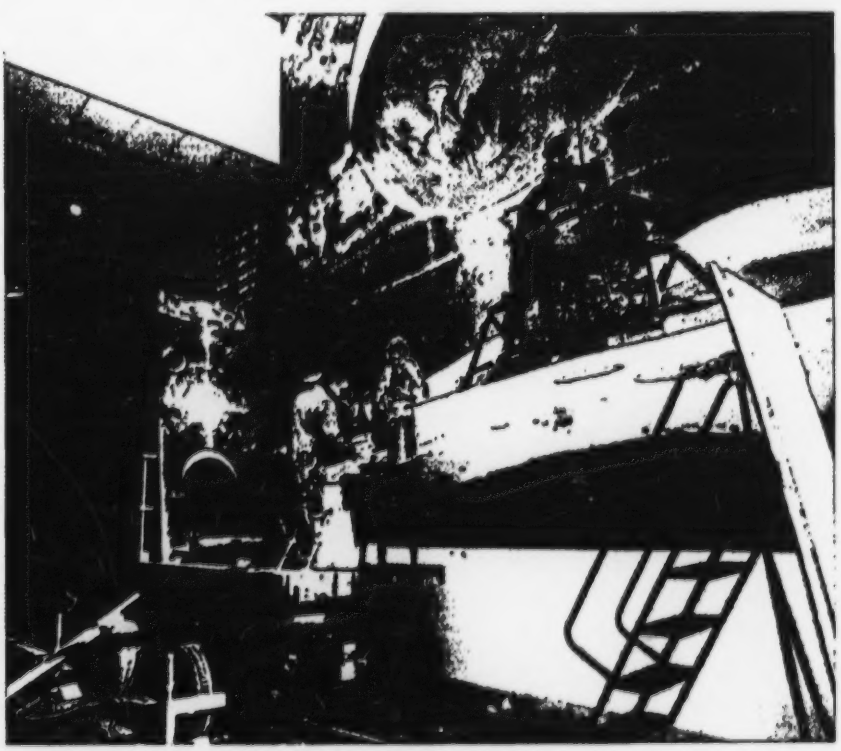
AN ARTIST ON MARS

FOR MORE THAN THIRTY YEARS, PAINTER ROBERT MCCALL HAS been to outer space what Frederic Remington was to the Old West—a romantic chronicler of life on a frontier. His are probably the best-known artistic conceptions of the space program, or the "space adventure," as he calls it. They are seen in forms ranging from postage stamps to a six-story mural in the National Air and Space Museum.

His painting *Terraforming Mars,* a detail of which is on our cover, hangs at NASA headquarters in Washington. *Mars Metropolis: 21st Century,* on page nine, was an illustration for a recent *New York Times Magazine* article on NASA's future. Because he has worked professionally at imagining communities on Mars, we got in touch with him to ask if he had any advice for students participating in the Mars Millennium Project.

"In one line, it would be to just give your imagination free sway," he said. "Don't be reluctant to let the thoughts come, however strange they might seem. I firmly believe that humankind has produced such wonders that almost anything the human mind can imagine is a possibility, given the time and determination and energy."

To students who are designing an entire Mars community, he had this to say: "Try to imagine what everything would look like, and *why.* I develop a rationale for everything. If someone were to point and say, 'What is that?' I could say it's a fuel cell, or an antennae directed toward planet Earth."



Robert McCall at work on *The Space Mural—A Cosmic View* in the National Air and Space Museum.

Mr. McCall grew up in Columbus, Ohio, where he began a career as a commercial artist before joining the Army Air Corps during World War II. A series of paintings of spacecraft for *Life* magazine led to his first commission from NASA. He has also served as a conceptual artist on a number of motion pictures, including Stanley Kubrick's *2001: A Space Odyssey.*

"Generally, my work is optimistic," he said. "In everything I do, I'm attempting to express my appreciation of the magic and wonder of the universe, and my thankfulness just to be part of it."

RESOURCES

BOOKS FOR TEACHERS

Bradbury, Ray, Arthur C. Clarke, Bruce Murray, Carl Sagan, and Walter Sullivan. *Mars and the Mind of Man.* Harper & Row, 1973.

Barbree, Jay, and Martin Caidin. *Destination Mars: In Art, Myth, and Science.* Penguin Studio, 1997.

Corn, Joseph J., and Brian Horrigan. *Yesterday's Tomorrows: Past Visions of the American Future.* Summit Books, 1984.

Sagan, Carl. *Cosmos.* Random House, 1980.

Watters, Thomas R. *Planets: A Smithsonian Guide.* Macmillan, 1995.

Wilford, John Noble. *Mars Beckons.* Alfred A. Knopf, 1990.

Zubrin, Robert, with Richard Wagner. *The Case for Mars.* The Free Press, 1996.

BOOKS FOR YOUNG PEOPLE

Fradin, Dennis Brindell. *Is There Life on Mars?* Simon and Schuster, 1999.

O'Shaughnessy, Tam, and Sally Ride. *The Mysteries of Mars.* Crown, 1999.

Schraff, Anne. *Are We Moving to Mars?* John Muir Publications, 1996.

Wunsch, Susi Trautman. *The Adventures of Sojourner.* Mikaya Press, 1998.

ELECTRONIC RESOURCES

There are scores of Web sites devoted to Mars. The great gateway to all of them is the NASA site. **www.nasa.gov**

The National Air and Space Museum offers lesson plans and activities based on online images of Mars. **http://www.nasm.edu/ceps/slimages**

If you'd like expert advice on your project,the Museum of Science in Boston has a pen-pal program that teams elementary-school students with scientists. For information, go to their Science-By-Mail page. **www.mos.org.sbm**

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